Nanoparticle Exposure Assessment and Control

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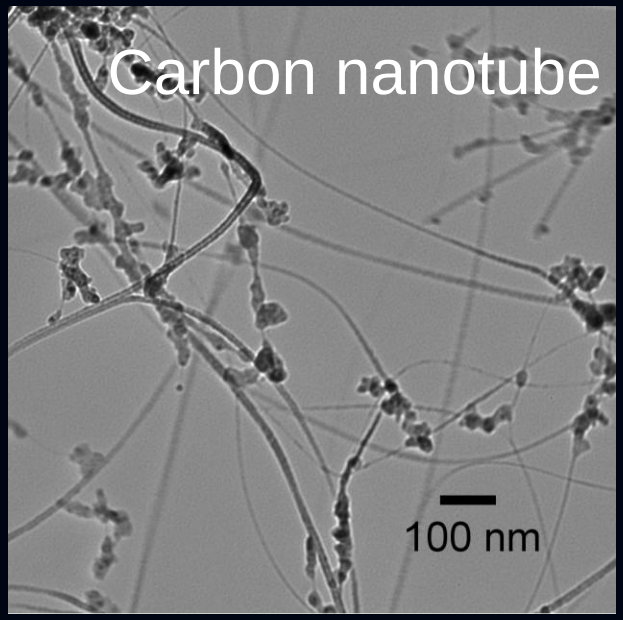
Center for High-rate Nanomanufacturing

What do we need to know?

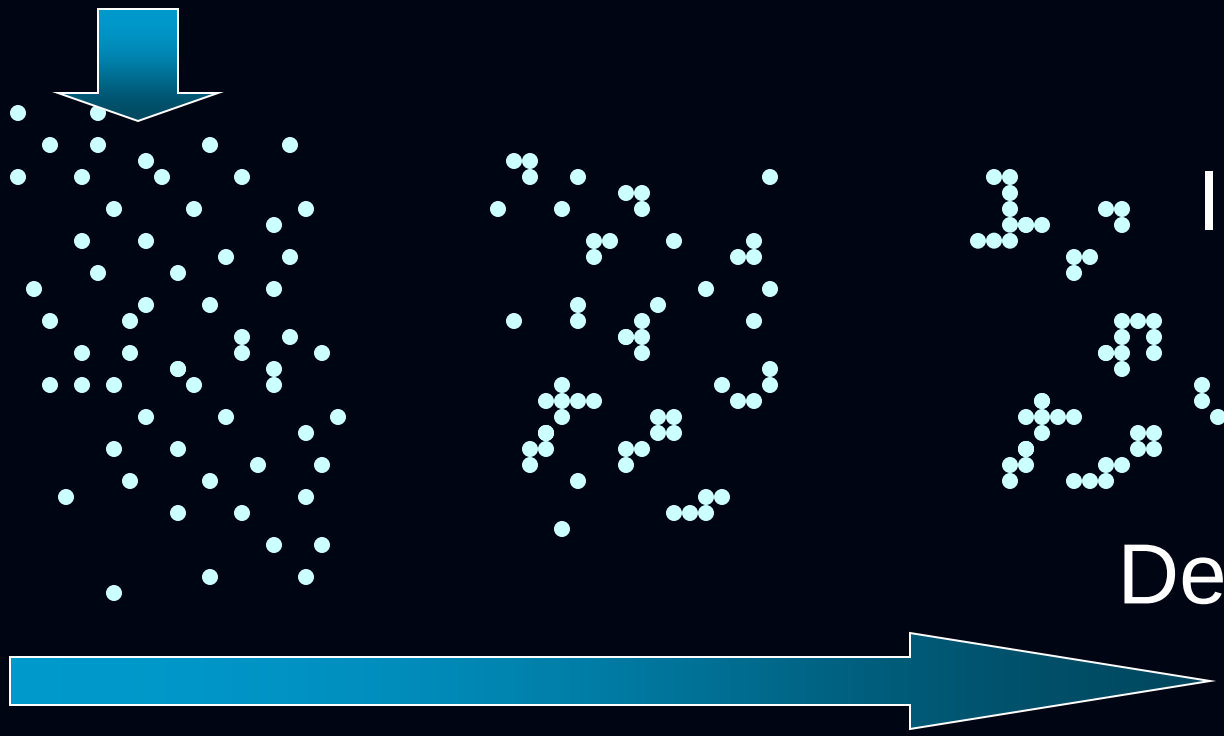
μm ⟶ nm

- Surface-to-volume ratio increases
- They may become more biologically mobile
  - Cross cellular boundaries from the alveolar region into the circulatory system
  - Pass through the skin
  - Travel through the olfactory nerve to the brain

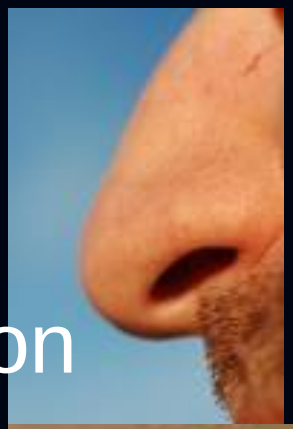


How are we exposed?

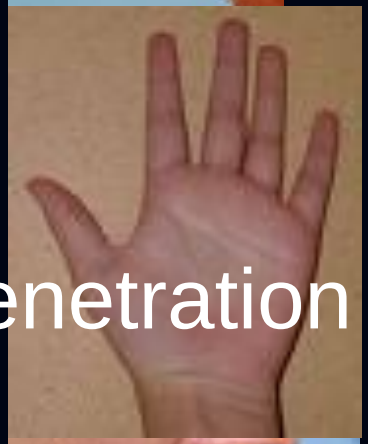
Released nanoparticles



Inhalation



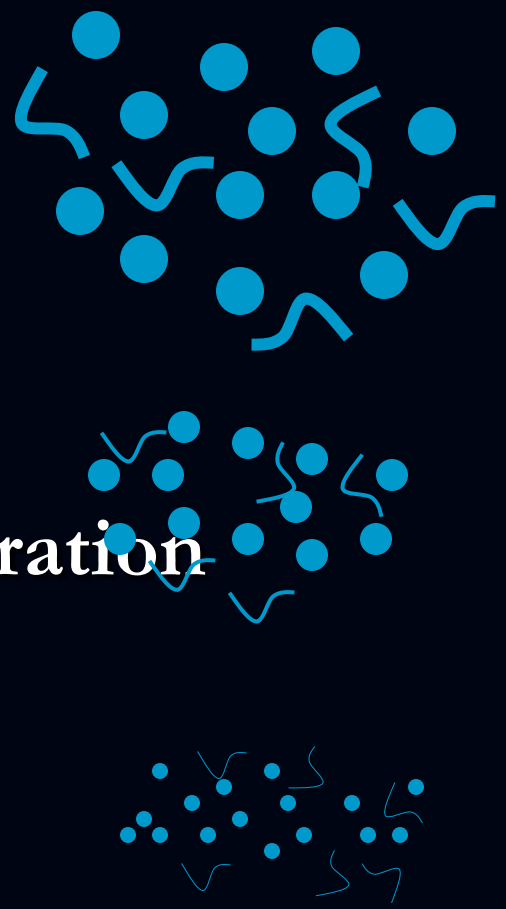
Dermal penetration



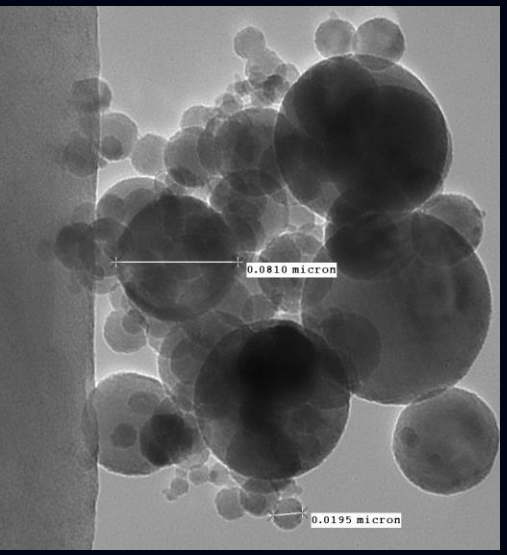
Ingestion

Measure Nanoparticle Aerosols?

- Mass concentration
- Surface area concentration
- Number concentration
- Particle size distribution
- Total particle number concentration
- Morphology
- Elemental composition



The Exposure Level



- Surface area concentration: may be of particular interest for nanoparticles, since some health effects are thought to be a function of particle surface area
- Number concentration: is useful to understand the quantity of nanoparticles
- Measure concentration as a function of particle size

Release source

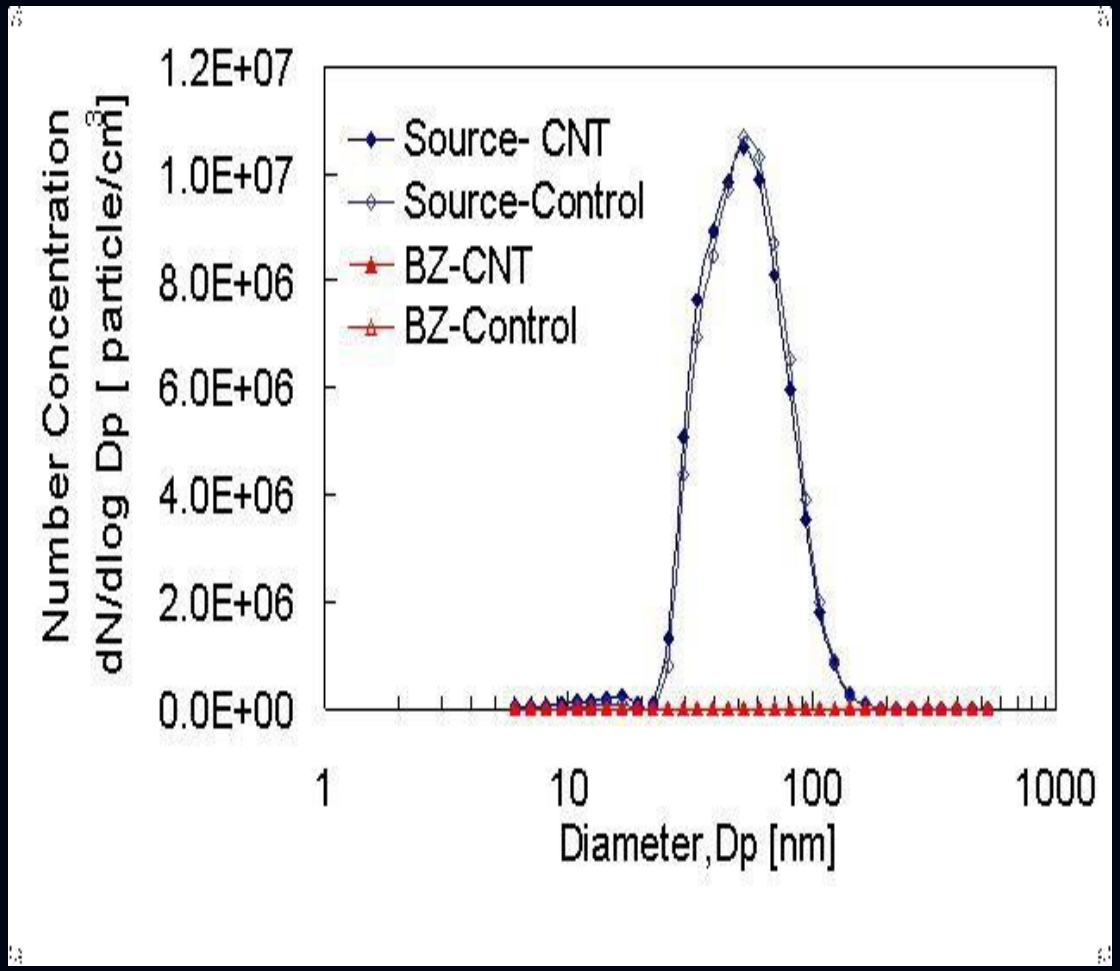
Collect airborne nanoparticles

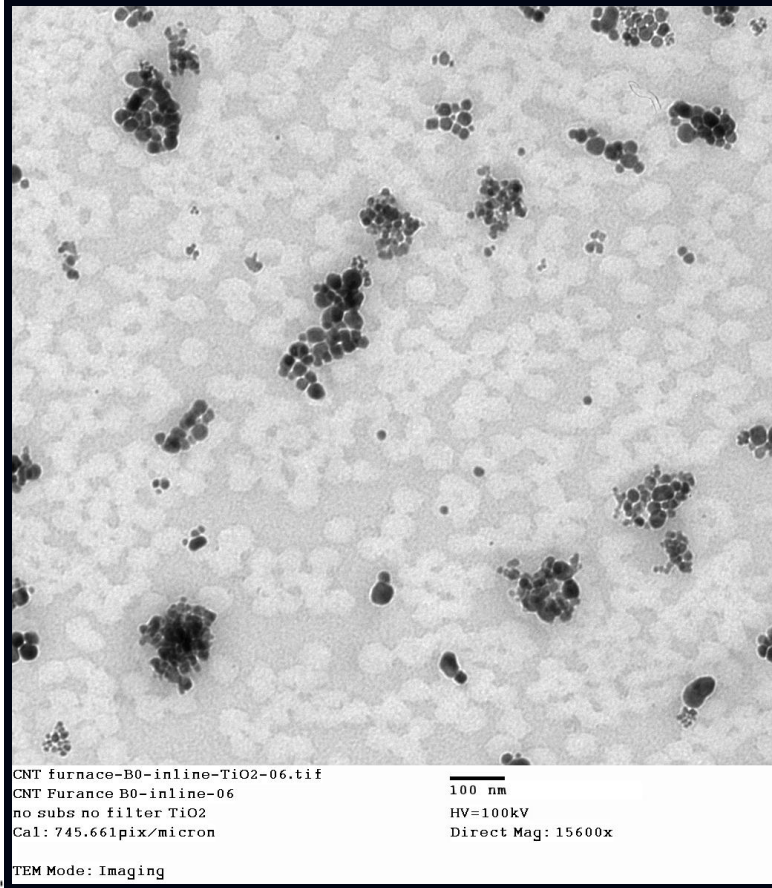
Measure airborne nanoparticle concentration

TSI Aerodynamic Particle Sizer Spectrometer (APS)

TSI Fast Mobility Particle Spectrometer (FMPS)

What was exposure?

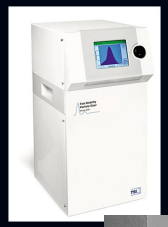




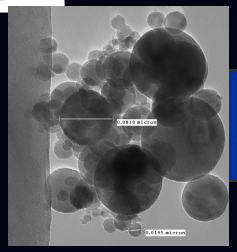
Exposure Assessment Model

1. Identify Potential Exposure

2. Examine Background Issues



3. Monitoring & Collect Particles



4. Characterize Particles

5. Evaluation & Further action

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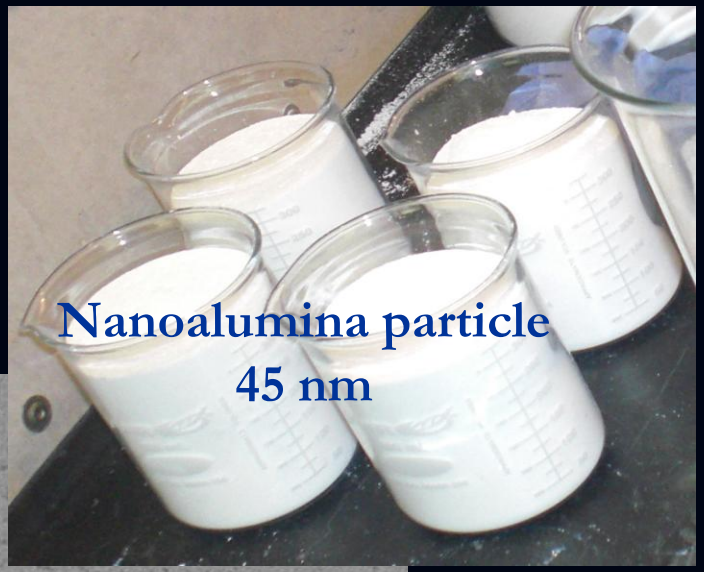
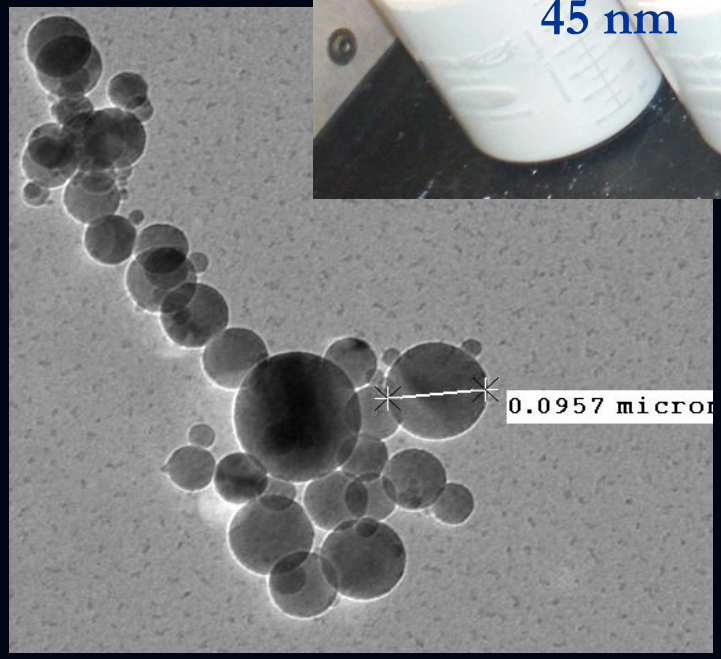
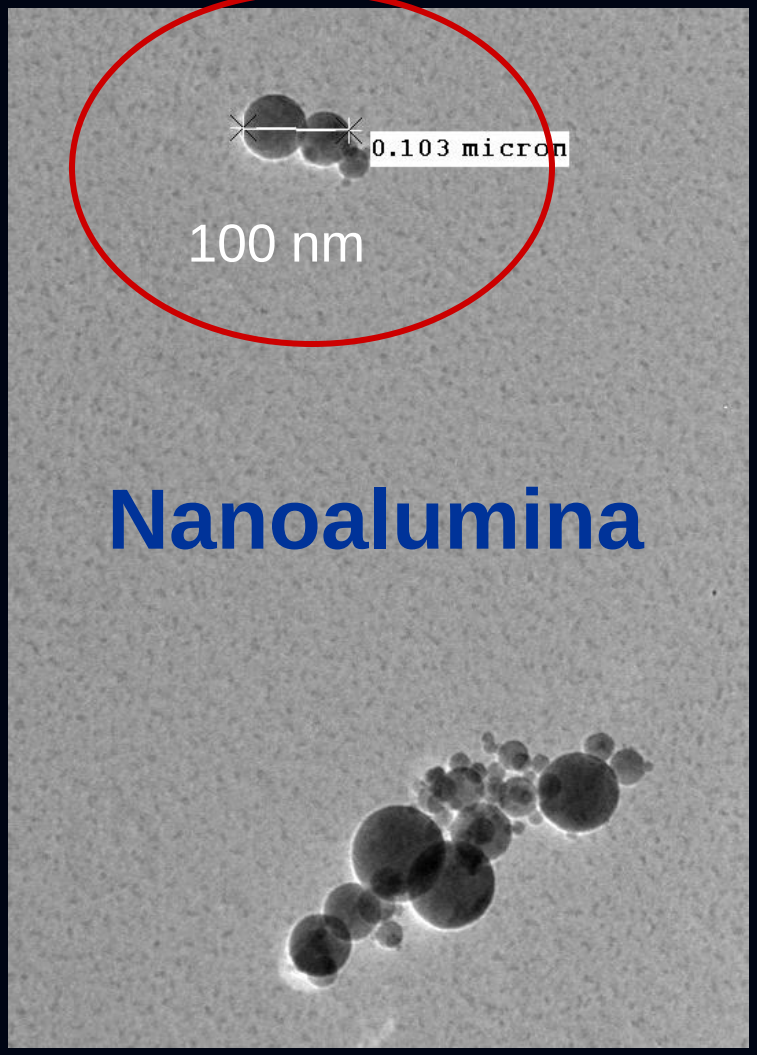
Sampling and Characterization

- Direct method
  - Directly collect airborne nanoparticles on TEM grids.
- Particle morphology and elemental analysis
  - Transmission electron microscope (TEM), Scanning Electron Microscope (SEM), Energy Dispersive Spectroscopy (EDS)

Airborne Nanoparticles- TEM







Hierarchy of Control Methods

Engineering controls

- Substitution
- Isolation
- Filtration
- Ventilation
  - General exhaust ventilation
  - Local exhaust ventilation

Administrative controls

- Worker training
- Medical monitoring
- Scheduling

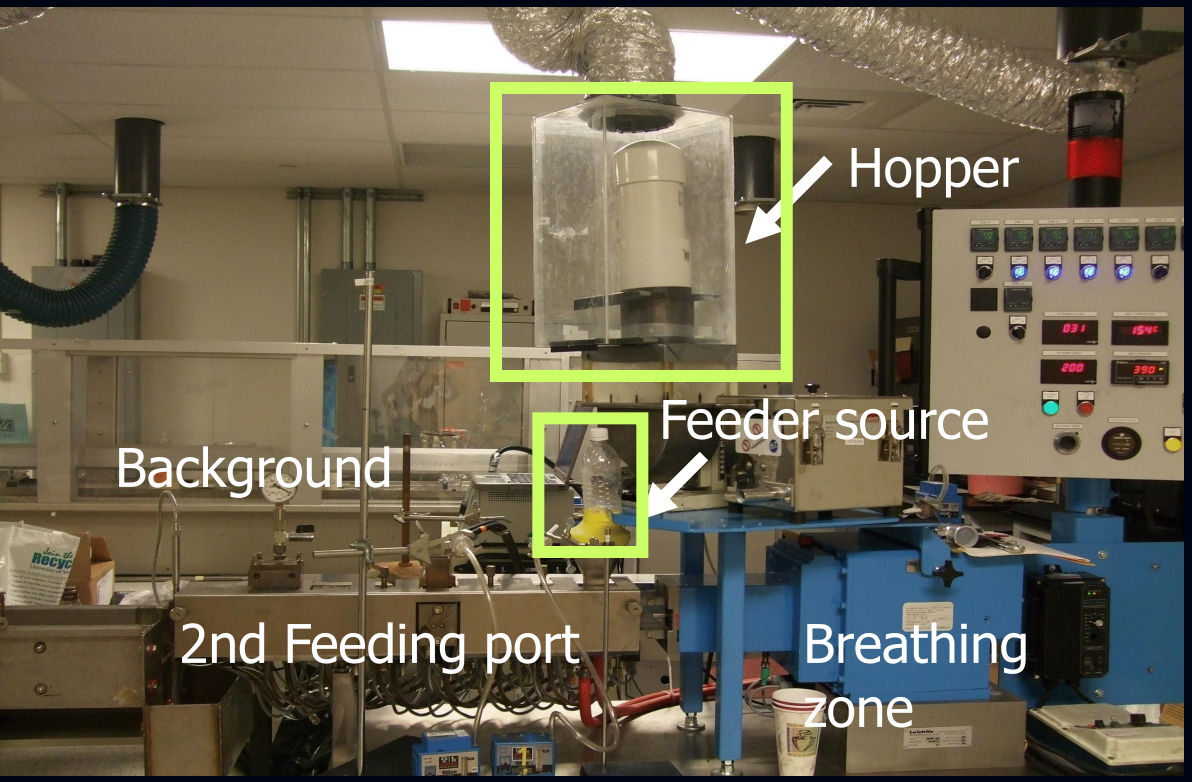
Key Elements to Control Exposure

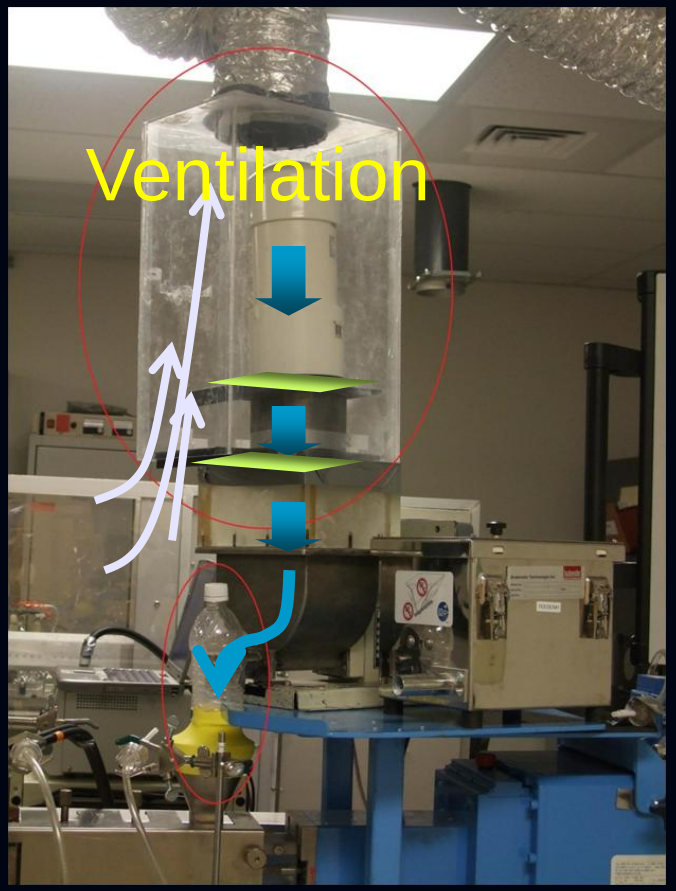
- Airborne nanoparticles behave very much like gas molecules
- Therefore, standard engineering control methods developed for gases should work well to protect workers from exposure to nanoparticles
- Air flow pattern plays an important role
- Agglomerate or not?

Isolation and Ventilation

Apply to Compounding Process
using Twin Screw Extruder:

Isolation +



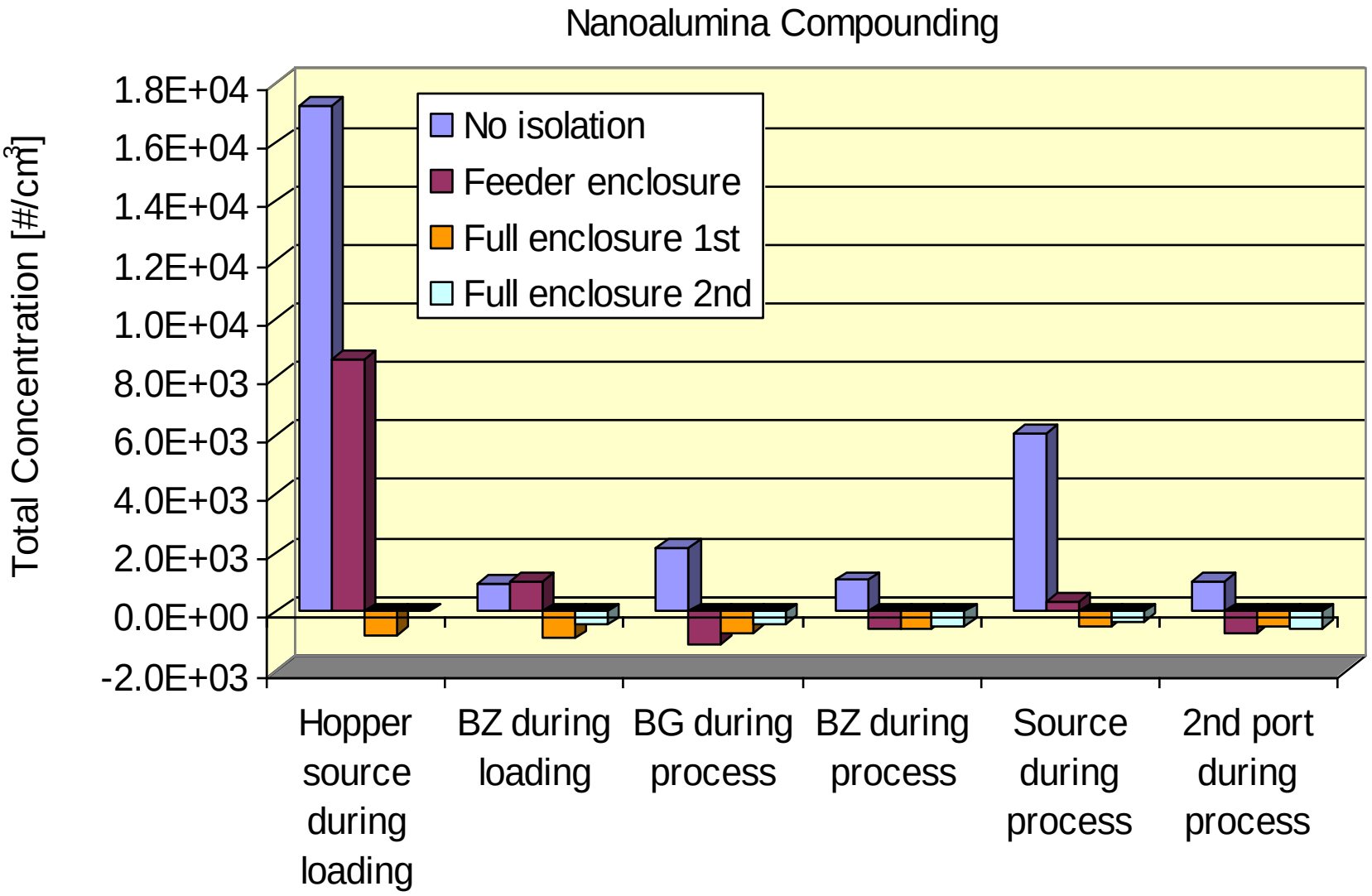


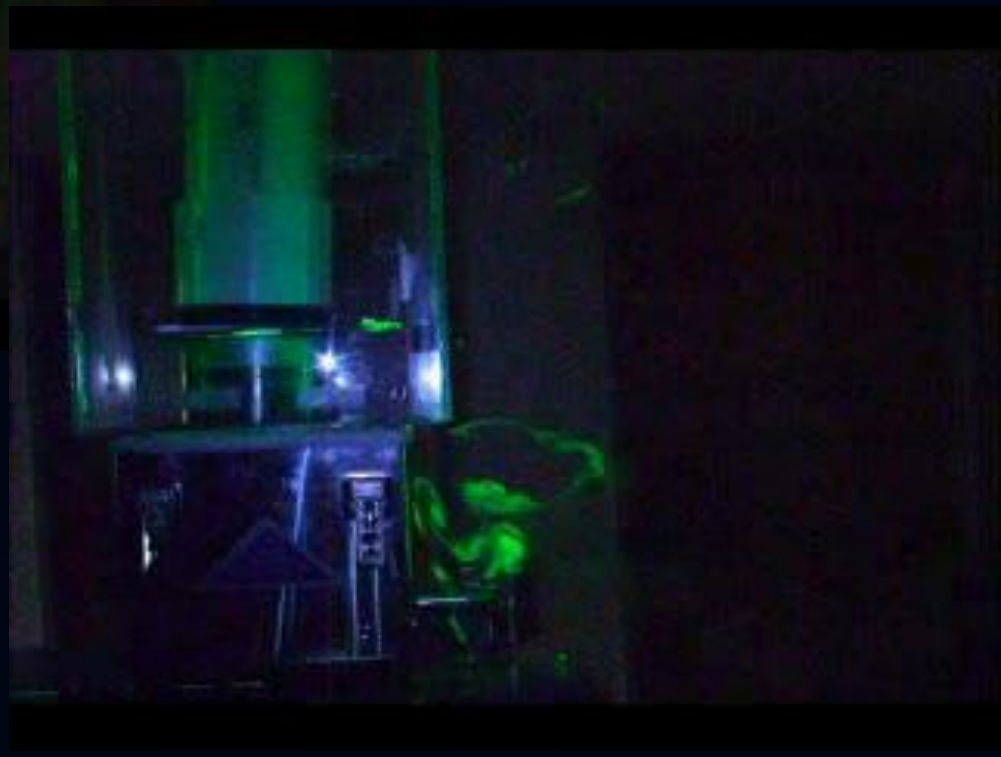
To the ventilation duct
- Air flow velocity: 2100 fpm
- Airflow rate: 400 ft^3/min (cfm)

Similar reduction of emission for nanoclay compounding.

Results

Particle total number concentration change





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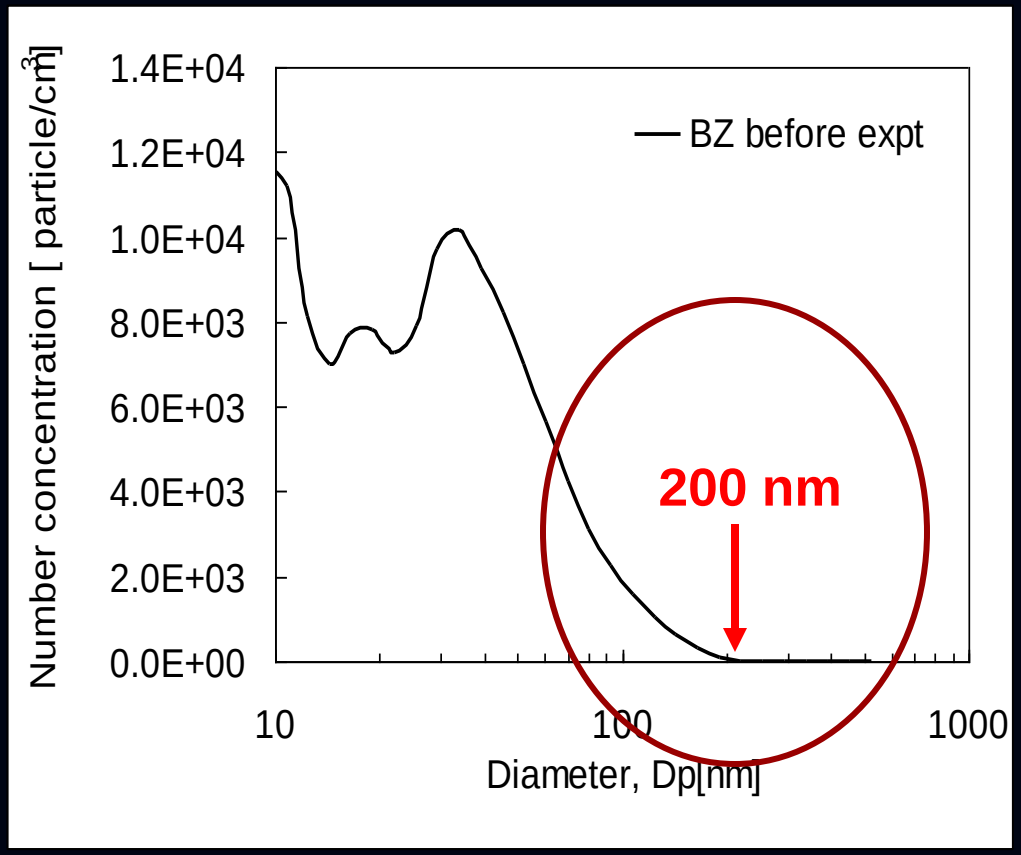
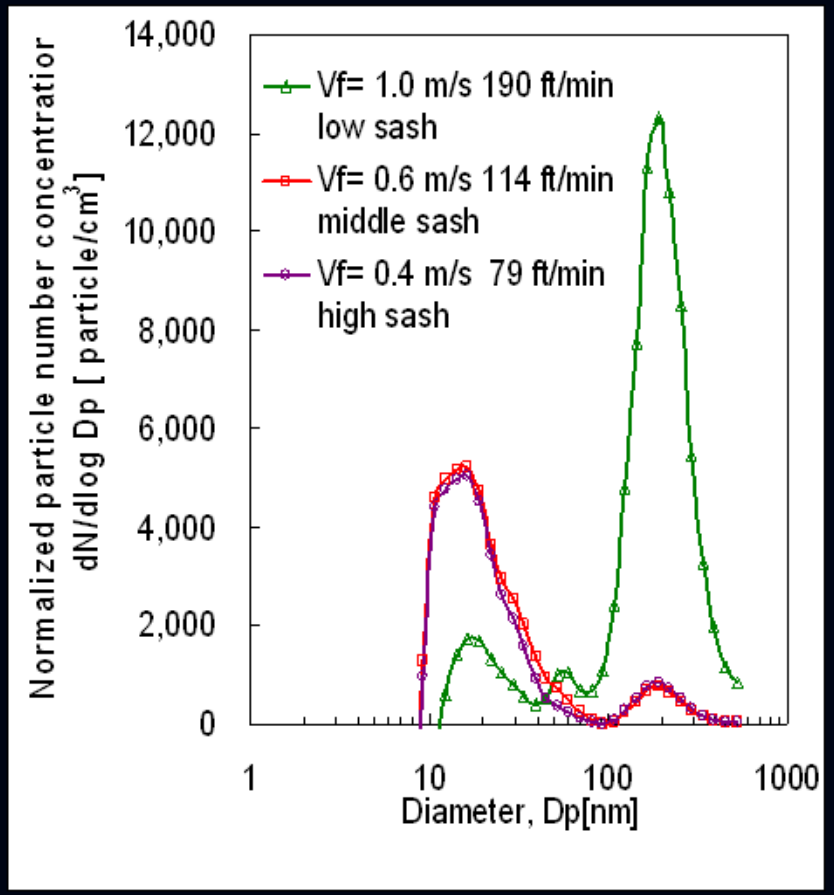
Local Exhaust Ventilation-Fume Hood

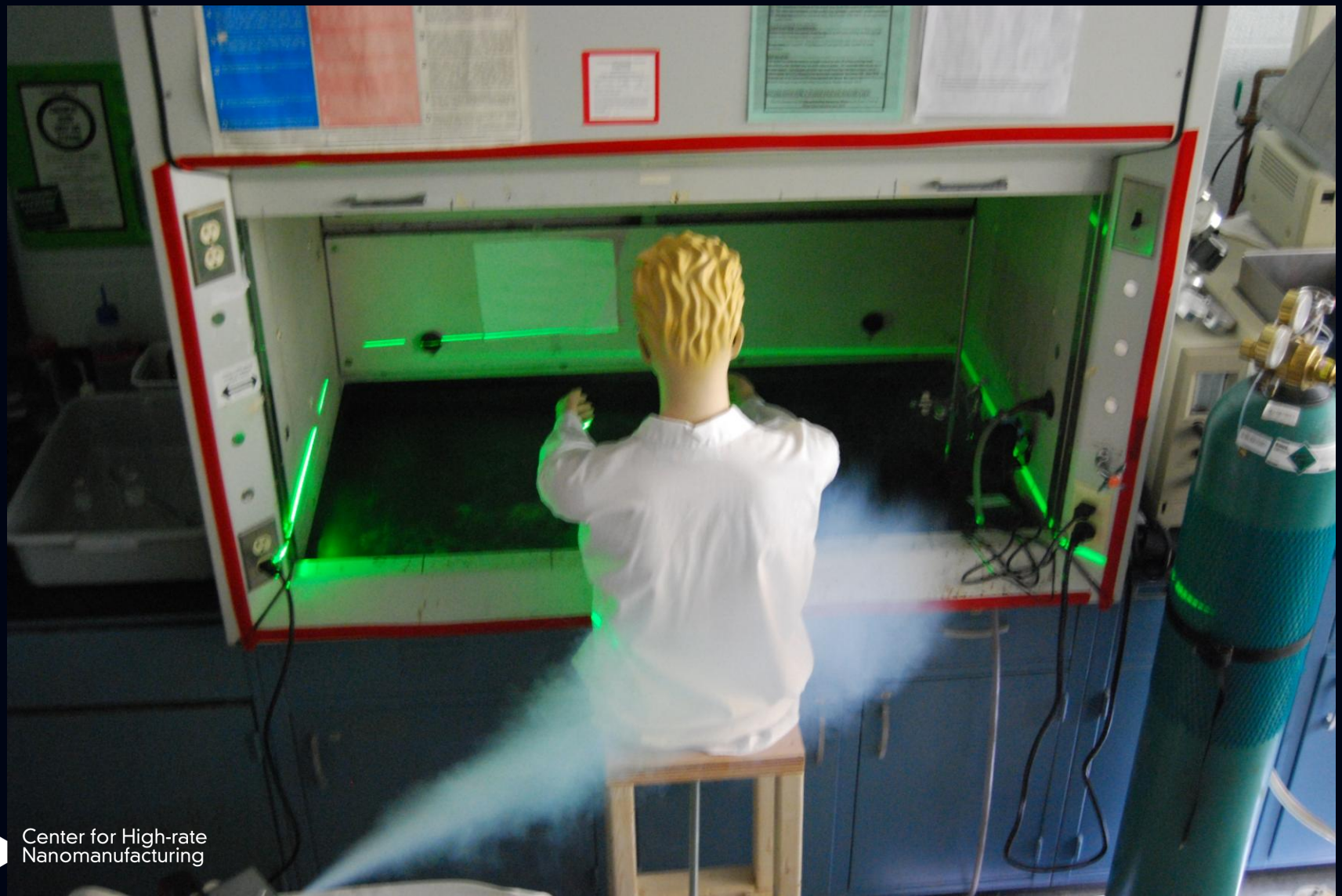
Background concentration at breathing zone





Reference: Tsai *et al*. J. Nanoparticle Research, July 2008

Exam Airflow Pattern



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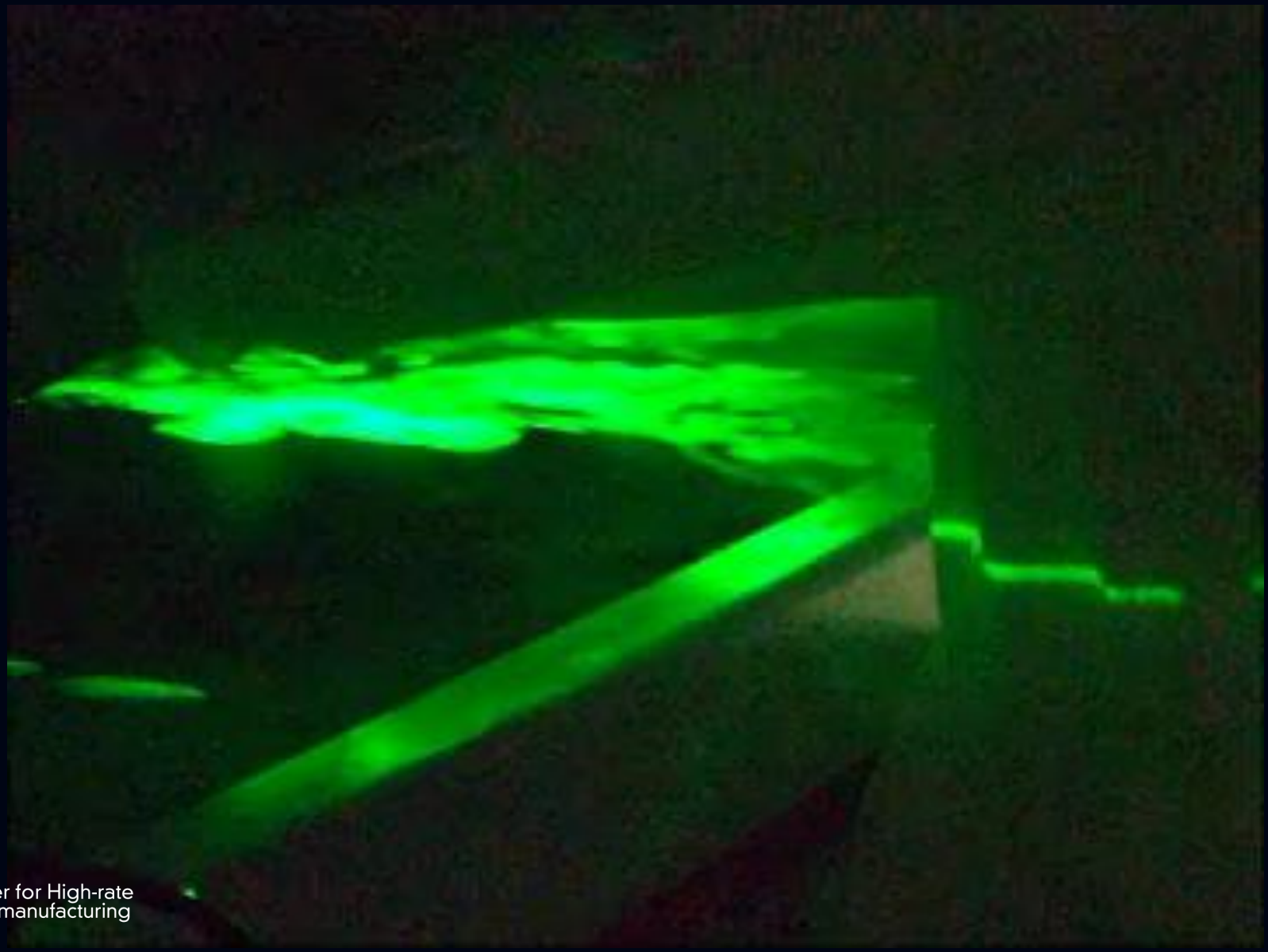
Horizontal Plane-
Constant Volume Hood



Vertical Plane-
Constant Volume Hood

Biological Safety Cabinet

High Performance Hood

- Air curtain hood
- Powder handing enclosure
- Nano hood
- Biological Safety cabinet

* Conclusion was made according to the evaluation results on hoods provided from manufacturers.
* Services can be provided through CHN-NHC (Nanomaterial Health Consortium)

Filtration

Apply to Exhaust Gas of CNT Furnace:

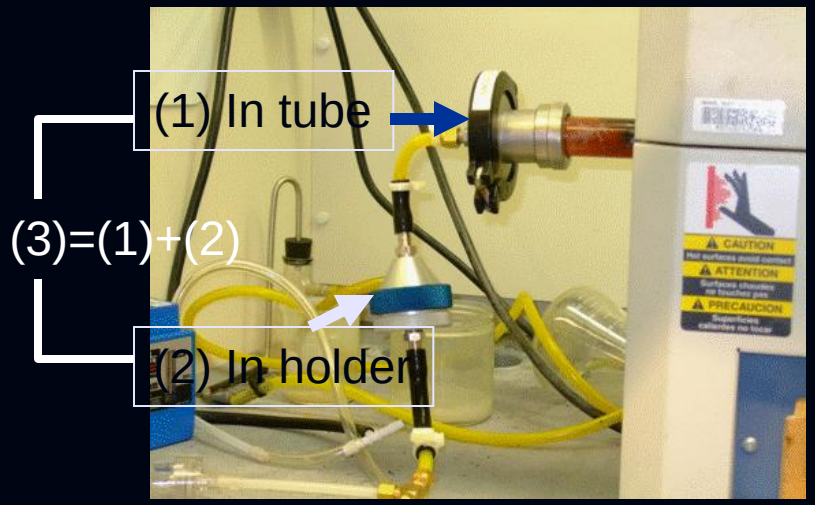
3 filters evaluated:

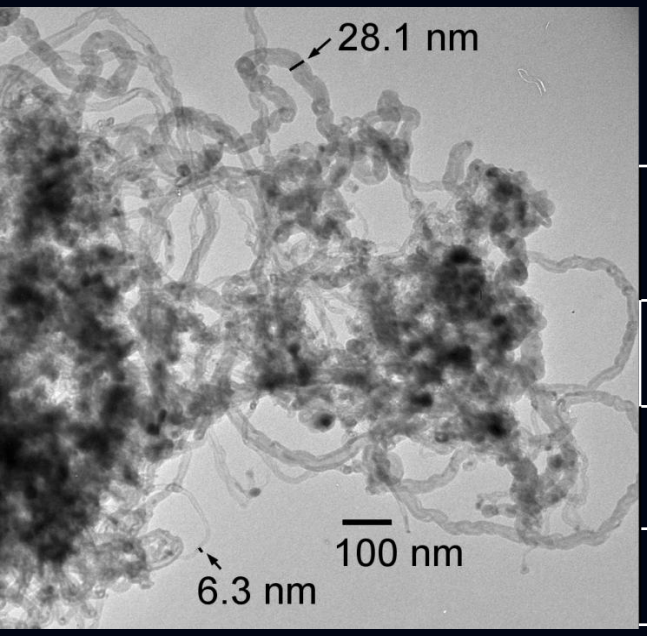
Nalgene® surfactant free cellulose acetate (SFCA)

Pall® A/E fiber glass (A/E)

Whatman® QMA quartz fiber (quartz)

3 methods applied:



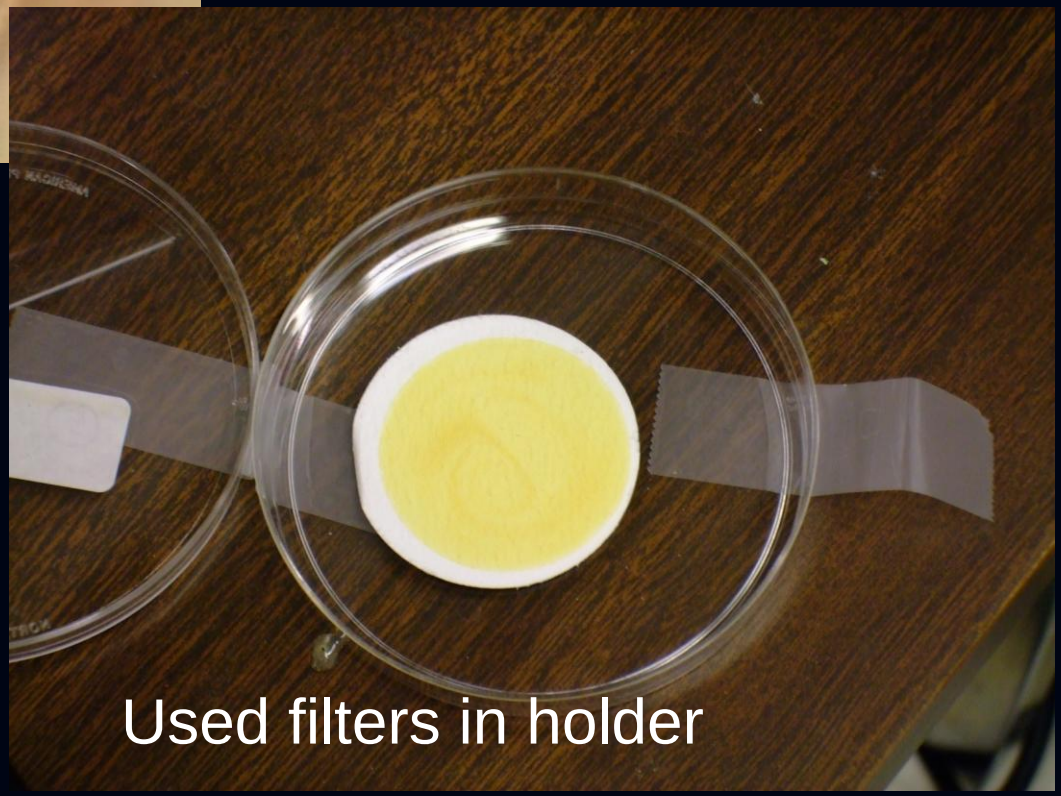


Particle Reduction %

Filter type	Single filter in tube (1)	Single filter in holder (2)	Double filter (3)
SFCA	39	48	68
A/E	58	32	59
Quartz		97	98

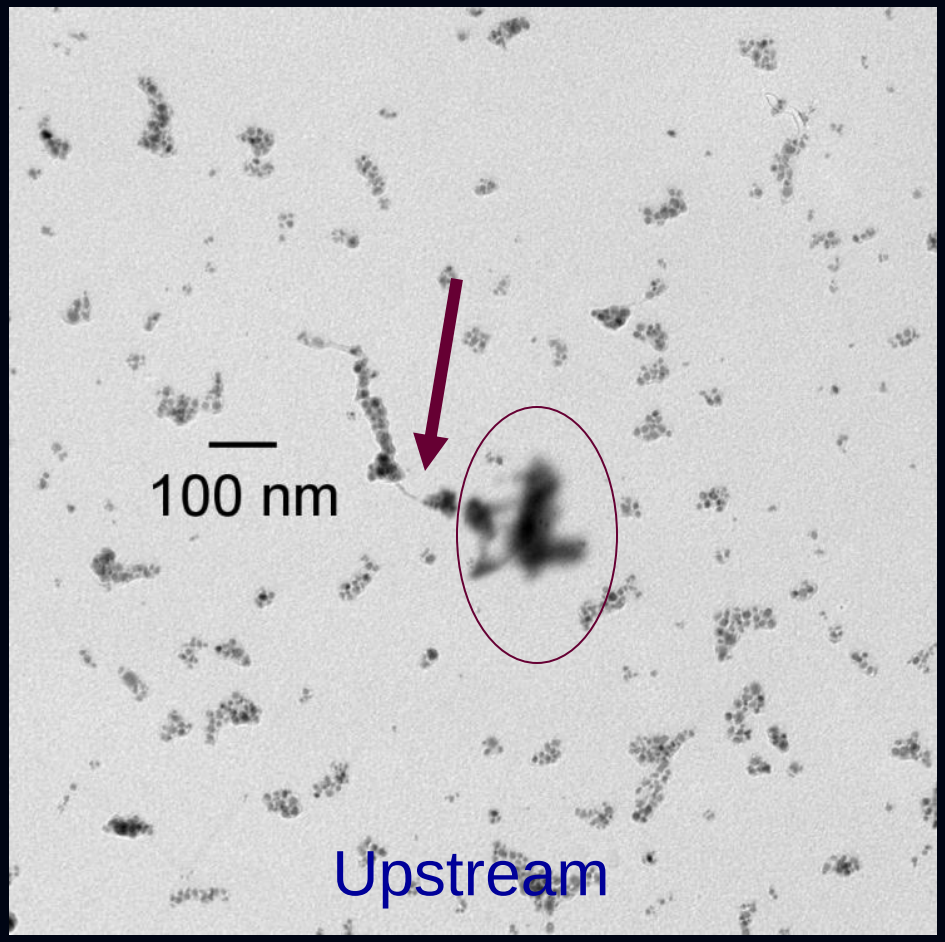
Reduction of total particle number concentration of 5-560 nm

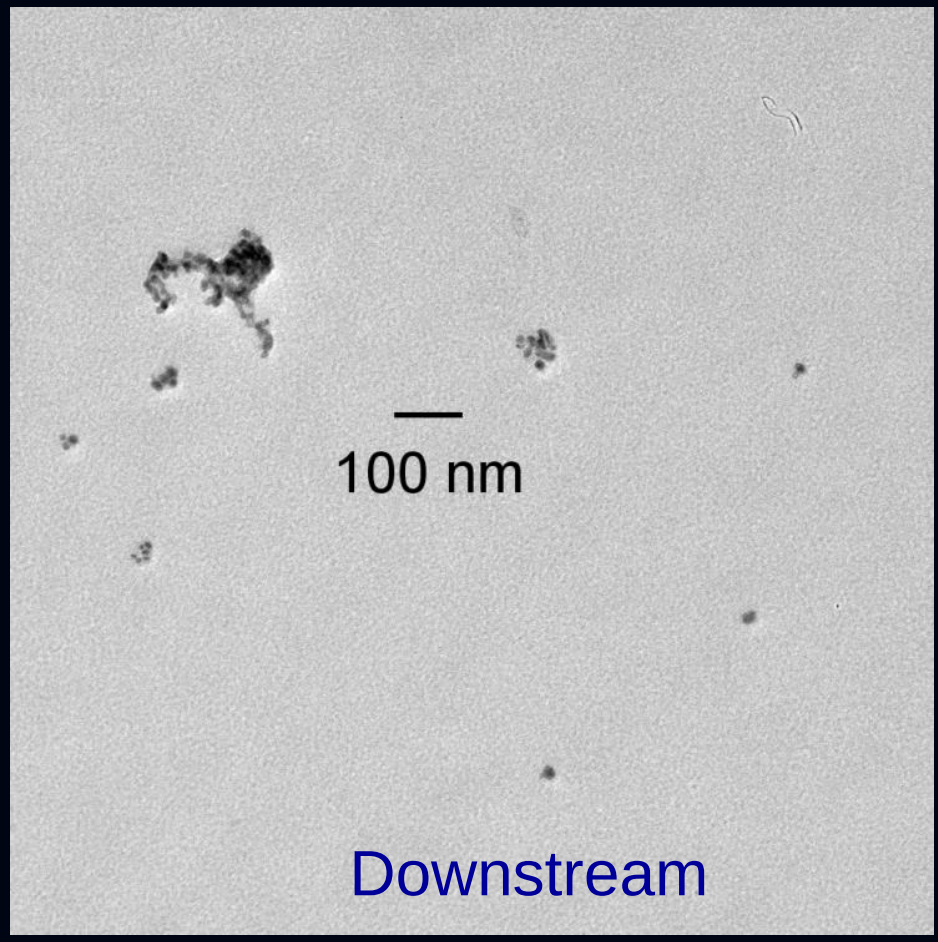
Used SFCA filter in tube



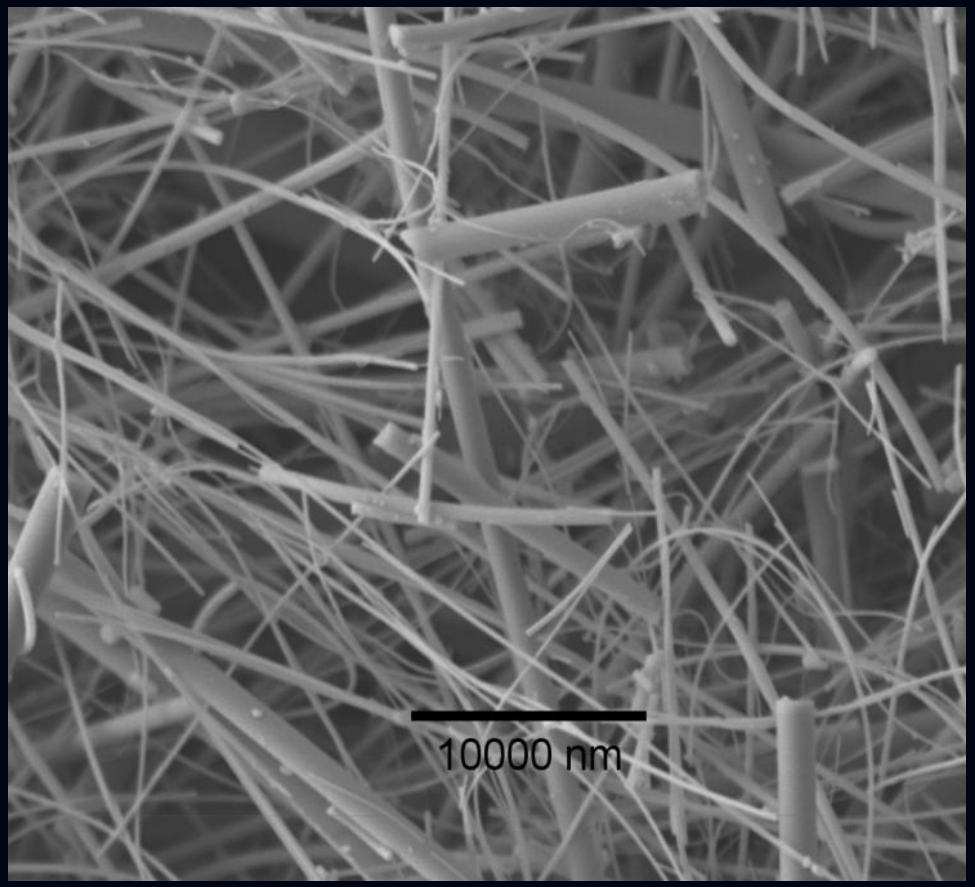
Used filters in holder

- Iron-encapsulated carbon and catalyst nanoparticles and filaments, SFCA filter use

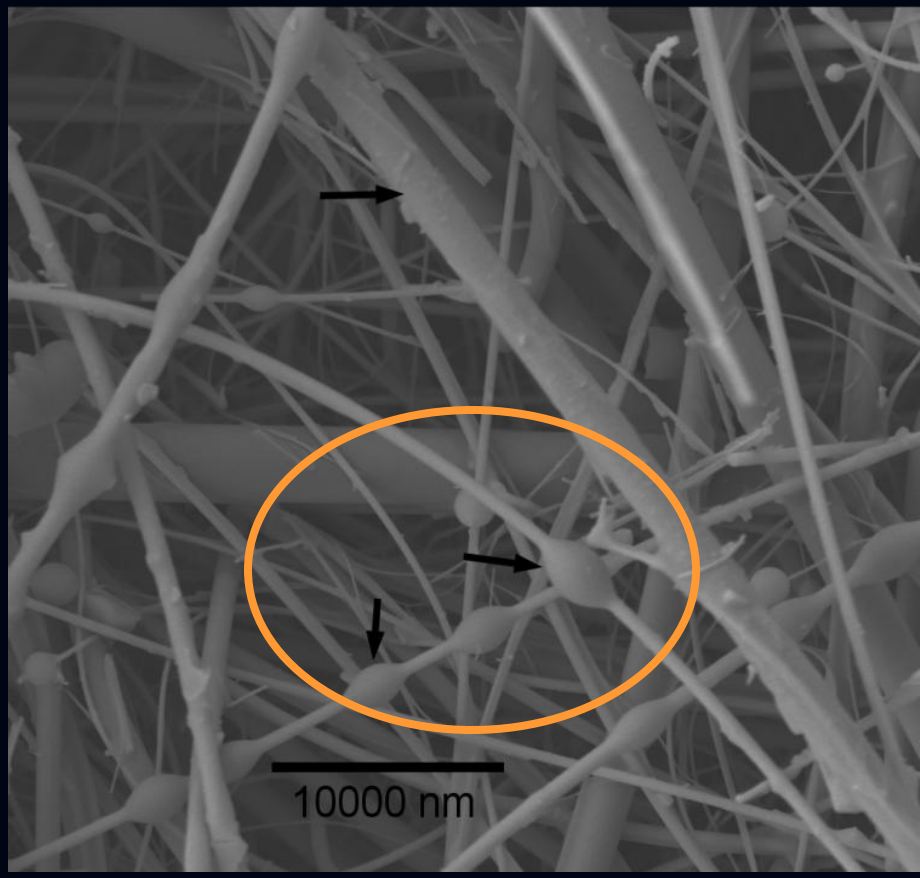




A/E fiber glass filter



Before use



After use

Administrative Controls

- Worker training
- Proper labeling
- Personal Protection Equipment use
- Material Safety Data Sheets (MSDS)
- Medical/biological monitoring
- Proper work practices

Discussion & Next Step

- Nano-enabled products are in rapid growth.
- Nanotechnology will benefit us by its features, but how about controlling exposure?
- **Characterize effective control strategies for various exposure scenarios. What do we need now?**
- How about policy for exposure and control?

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Boston, MA

Chairs: Dr. Tsai and Dr. Ellenbecker

www.uml.edu/nano/nanoehs

Q & A

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